NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE SPECIFICATION

WINDBREAK/SHELTERBELT ESTABLISHMENT

(Feet)

CODE 380

GENERAL SPECIFICATIONS

Procedures, technical details and other information listed below provide additional guidance for carrying out selected components. This material supplements the requirements and considerations listed in the conservation practice standard.

General Criteria Applicable to All Purposes

The location, layout, and density of the planting will accomplish the purpose and function intended within a 20-year period. Specifications for in-row tree/shrub spacing should be that crown closure will occur within this period. Spacing between individual plants shall be based on the needed growing space for plant type and species, the accommodation of maintenance equipment, and the desired characteristics of the stem(s), branches and canopy as required for a specific purpose. The maximum design height (H) for the windbreak or shelterbelt shall be the expected height of the tallest row of trees or shrubs at age 20 for the given site (see W*indbreak Suitability Groups*, Colorado Technical Guide II-Windbreak Interpretations, Notice No. 327, for expected heights).

The following guidelines will assist in development of specifications for windbreak/shelterbelt sites.

To provide adequate protection from wind and drifting snow around buildings, feedlots, etc., a dense windbreak (greater than 65% density) is needed. A minimum of two rows will generally be required, of which the windward row should consist of a shrub or short, dense tree species. Optimum effect will be achieved by planting 3 or more rows

A windbreak may consist of one or more legs, depending upon the number of directions from which troublesome winds occur. Design the windbreak so that at least one leg is close as possible to a right angle to the prevailing problem wind.

In addition, the windbreak must have sufficient length to place the majority of buildings, feedlots and other areas needing protection within the 2-5H wind shadow zone. Due to the shifting nature of the wind, extend the ends a minimum of 150' past the edge of the area needing protection where property boundaries allow.

Figure 1 on the next page shows possible alternatives.

Spacing between the Rows

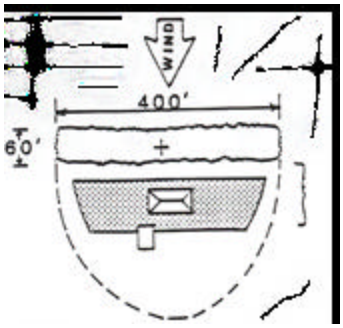
In multiple row windbreaks, between row spacing should result in crown closure between the rows at maturity, but allow adequate space for the trees/shrubs to grow. Crown closure will result in shading the soil within the windbreak to control vegetative competition when the windbreak is mature. Long-range management of a windbreak may include thinning when competition between trees/shrubs hinders growth and health of individual trees/shrubs. The spacing between rows in a multi-row windbreak should allow for the operator's planned cultivation equipment plus 4 feet. Where mulches are used with between row cultivation, the between row distance should include the width of the mulch and the width of the equipment. Fast growing tree species with an overtopping growth habit, such as Siberian elm and Green ash should not be planted within 25 feet of other species.

Spacing between rows except for twin row high density shall be as shown below.

Shrubs	8-20 ft.
Low Broadleaf (<25' ht.) & Junipers	12-24 ft.
Broadleaf * & Conifer Trees	16-30 ft.

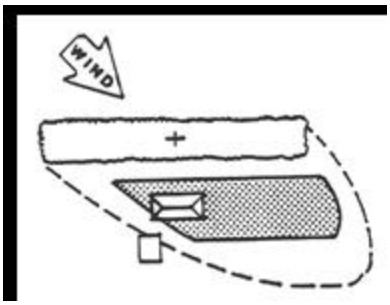
A trip row of shrubs located a distance to the windward side of a multiple row farmstead/feedlot windbreak can help catch tumbleweeds and prevent some snow from accumulating within the windbreak. A longer distance between this row and the main windbreak can allow tumble weeks to be removed periodically with equipment

Farmstead and Feedlot Windbreaks

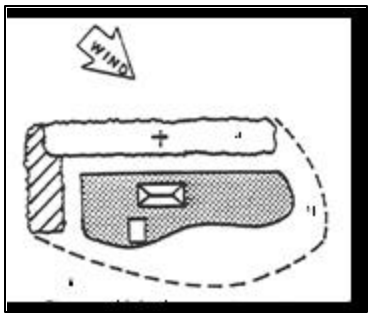


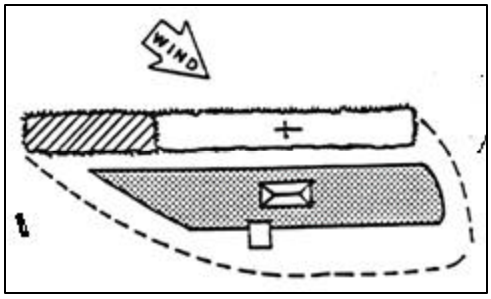
2-5H Zone of Maximum Protection from Wind (Scale: 1" = 200 ft.; dashed line is 10H wind shadow boundary).

Adequate protection and no snow deposition problems for a one-leg windbreak with a single-direction wind. If the wind shifts……



inadequate protection with snow drifting potential on one side results.





Making a two-leg windbreak …or extending the one-leg windbreak can solve this problem.

FIGURE 1

Spacing Between Plants Within Rows

Suggested spacing in the rows of mature multiple row farmstead and feedlot windbreaks is as follows:

1. 3-6 feet for low shrubs.
2. 6-8 feet for eastern redcedar, Rocky Mountain juniper and tall shrubs.
3. 8-14 feet for low deciduous trees with a height capability of less than 25 feet at 20 years.
4. 10-16 feet for tall evergreen trees.
5. 10-18 feet for tall deciduous trees with a height capability of greater than 25 feet at 20 years.

For single-row plantings including field windbreaks: Tall shrubs, junipers and cedars should not be spaced more than 8 feet apart. Tall deciduous and evergreen trees should not be spaced more than 12 feet apart. Seldom will a low shrub be planted as a single row windbreak.

For 2-row field windbreaks, recommended spacing between trees and shrubs in the row is as follows:

1. Low shrubs, 4-6 feet.
2. Tall shrubs, 8-12 feet.
3. Tall deciduous trees, 12-16 feet.
4. Tall evergreen trees, 12-16 feet.

Suggested row arrangement for multiple row windbreaks:

PLANT	WIDTH OF BELT (number of rows) 2	4	6	8	10
Cedar or Juniper	1-2	1-2-3	1-2-6	1-2-3-8	1-2-3-7-8-9-10
Pine	1-2	3-4	4-5-6	6-7-8	7-8-9-10
Low deciduous	2	3-4	3-5-6	3-8	3-10
Medium to tall deciduous	2	2-3	3-4-5	3-4-5	3-4-5-6
Shrubs	1	1-4	1-2-6	1-2-7-8	1-2-7-8-9-10

Row 1 is the windward and outside row. For a 3-, 5-, 7-, or 9-row windbreak, eliminate row 3 of a 4-, 6-, 8-, or a 10-row windbreak in the above table.

Secondary windbreaks may consist of one or more rows of adapted tree or shrub species.

TWIN-ROW, HIGH-DENSITY DESIGN

Twin-row high-density plantings are an alternative design for windbreaks. This specialized design is actually a series of individual windbreaks within a large planting. The configuration is achieved with sets of two closely spaced tree rows, and a wide gap between each set. This design shall be installed when there is a need for quick crown closure, for instance in a new living snow fence. Where there is concern about trees being planted too close together in twin rows, do not use this design.

"Twin-row" refers to two closely spaced rows of trees or shrubs having the same growth rate, crown characteristics, and life spans. Both rows of a twin row should be of the same species. Large spreading trees such as cottonwoods, Siberian elm and tree-type willows are not recommended in twin-row plantings.

"High-density" refers to the close spacing of trees or shrubs in each twin row. The two rows of a twin-row are normally spaced 6 feet apart but may be spaced 4 feet for shrubs and up to 10 feet apart if room is needed to mechanically install synthetic mulches. Plants in each row are planted 3-10 feet apart depending on mature plant size. This density results in quick crown closure that may be desirable in projects such as Living Snow Fences.

In twin-row, high density planting, the concept is that while trees/shrubs are planted close together in twin rows, there will be room for root development in the space between the individual windbreaks in the planting. The open space between twin-row plantings may vary from 25-150 feet apart depending upon objectives. The 25 feet distance should only be used with shrubs. Common between twin-row distances are 40 -50 feet. Wider between twin-row distances will only be used in areas that receive high snow accumulation amounts on an annual basis.

Once seedlings are established, clean tillage of open areas between twin-rows may be needed to result in good tree/shrub vigor. Annual crops might be planted in this space for production or wild life food and cover.

A twin-row, high-density example is listed below.

Twin-row A – Shrubs
(Windward Row)
25-50 feet

Twin-row B – E. redcedar or Rocky Mt. Juniper
40-50 feet

Twin-row C – Low deciduous tree
40-50 feet

Twin-row D – Pine, Spruce, or tall deciduous tree.

Additional twin-rows may be added leeward of Set D.

Within-the-row spacing (to create required densities and between crown fill in within sets of twin rows):

Shrubs – 3-4 feet
Junipers and low deciduous trees – 4-6 feet
Pine, Spruce, and tall deciduous trees – 5-10 feet

A single twin row high-density windbreak may be used where insufficient space is available. Only eastern red cedar or Rocky Mountain juniper is suggested in this type of planting.

Species Selection
Species must be adapted to the soils, climate and site conditions. Species shall be suited for the planned practice purpose(s).

Selection of species to achieve wind protection and other objectives should be made using the Field Office Technical Guide (FOTG), Section II-N.

Location
Avoid planting trees or shrubs where they will interfere with structures and above or below ground utilities. For plantings adjacent to over head lines, position shrubs or trees so that crowns (projected crown height and diameter at 20 years of age) are at least 20 feet from the nearest line or structure. If space is limited, species with a mature height less than the height of the facility may be used beneath above ground utilities. Avoid planting trees and shrubs within 20 feet of underground septic lines where possible.

Comply with applicable federal, state and local laws and regulations during the installation, operation, and maintenance of this practice. Avoid creating blind corners at road intersections. On the windward side of a road, the nearest tree row should be no closer than 50 feet from the edge of the right-of -way. On the windward side of a road in areas having heavy snow accumulation annually, tree rows should not be planted closer than 200 feet from the centerline of the road to provide adequate snow storage off the road. Where space allows, plantings on the south side of roadways should be 100 feet from the center line of the road to avoid ice buildup from winter shading and snow drifting.

Preparation of Planting Sites
Site preparation shall be sufficient for establishment and growth of selected species, not contribute to erosion, and be appropriate for the site. Mechanical, manual, or chemical methods may be used for site preparation. Minimum area of site preparation for each tree or shrub shall be a 3 feet diameter circle.

Proper site preparation prior to planting trees and shrubs is critical to their survival and growth. Properly prepared sites are free of living sod and weeds. Soils will be in a settled condition at planting time. If a compacted layer exists, chisel or subsoil in the fall when the soil is dry. Tillage operations must be on the contour where practical when used on slopes $\geq$ 8% to avoid formation of gullies. (Caution: avoid cropland sites that have had recent heavy applications of herbicides that may be harmful to seedlings)

All site preparation will take cultural resources into consideration.

V ditching can be effective for water harvesting as part of site preparation. Caution must be taken to not make the V ditch more than 2 inches deep.

Planting sites shall be properly prepared based on the soil type and vegetative conditions listed below

Loamy/clayey Soils

Sod and alfalfa land

Summer fallow 1 year is preferred to kill the sod. Till in the spring prior to tree planting. A fall-sown crop of small grain may be used where needed to control erosion.

Sod may be killed by non-selective herbicides the year prior to tree planting. 2/ Plant trees in the residue. On heavy soils, tillage is usually necessary to achieve a satisfactory planting when a tree-planting machine is used.

Cropland

If the site is in row crop, till in the fall prior to planting

the trees. Check to see if the site has a plow or hard

pan in the subsoil; if it exists, a deep disking or ripping should be done in the fall. A fall-sown crop of small grain may be used where needed to control erosion.

If the site is in small grain stubble, the trees may be planted in the spring without further preparation.

Tillage operations on steep slopes must be on the contour or with terraces where practical. A cover crop between the rows may be necessary to prevent erosion.

Sandy Soils

Sod and Alfalfa Land

Till and plant to a spring cover crop (corn, grain, sorghum, etc.) the year prior to tree planting. Leave a stubble cover in which to plant the trees. A light disking may be needed before tree planting if fabric mulch is used.

Sod may be killed by non-selective herbicides 2/ the year prior to tree planting. Plant trees in the residue.

When hand planting, scalp or strip an area at least 36 inches in diameter and two to four inches deep. (Subsequent planting of the tree will be in the scalped area.)

Roto-till a 36-inch wide strip. (Subsequent planting of the tree will be in the tilled area.) Where a drip watering system will not be used, roto-till the strip the year prior to tree planting and keep clean tilled to allow accumulation of ground moisture.

Cropland

If the site is in small grain, corn or similar clean tilled crop, and it is reasonably free of weeds, plant trees in the stubble without prior preparation. It may be necessary to till a narrow strip with a disk or other implement to kill weeds or volunteer grain, or to prevent stalks and other residue from clogging the tree planter. If fabric mulch is used, disking may also be needed. A cover crop or stubble must be maintained between the rows to protect the trees from soil blowing.

- Non-tillage Sites and/or Erosive sites (because of steepness or other limitations)

On sites where it is not practical or possible to operate equipment, where tillage of the entire site will cause excessive erosion, or where tillage of the entire site is impractical, the following methods of site preparation may be used.

Scalp an area at least 36 inches wide the year prior to tree planting. (Subsequent planting of the tree will be in the center of the scalped area.)

Roto-till a strip at least 36 inches wide the year prior to tree planting. (Subsequent planting of the tree will be in the center of the tilled area.)

Kill the vegetation with a non-selective herbicide 2/ in a 36-inch diameter or larger area, or in a 36 inch or wider strip the year prior to tree planting and plant in the treated area..

Planting Stock

Only viable, high quality, and adapted planting stock will be used.

Bare root planting stock should be stored in a cool, moist environment (34-38 degrees F) or heeled in. Heeling in is necessary if planting is to be delayed more than one week. To heel in, remove seedlings from the bundle, spread them out in a trench, and cover the roots with soil. The trench should be located in a cool, shady place, and the soil around the roots needs to be kept moist. During all stages of handling and storage, keep stock tops dry and free of mold and the roots moist and cool. Stock that has been allowed to dry, to heat up in storage (e.g., within a bundle or delivery carton), or that has developed mold or other pests should be destroyed.

Live cuttings that will not be immediately planted should be promptly placed in controlled storage conditions (34-38 degrees F) and protected until planting time.

Containerized or potted seedlings should be stored where shaded and cool, but not inside buildings. Soil around roots should be kept moist.

Best seedlings are not less than 3/16” in caliper at 1” above the root collar. For cuttings, avoid using material less than ¾” in diameter, cut off tops with apical buds, remove side branches, and produce lengths long enough to reach adequate soil moisture required by the individual species during growing season. Tops of dormant-season collected cuttings

may be dipped into latex paint, paraffin or sealing wax to prevent desiccation and mark the up-end. Rooted planting stock should not exceed a 2:1 root-to-shoot ratio.

Planting

Planting holes or furrows must be deep enough so that the roots are not curled or crowded (planting into a narrow trench will accumulate extra moisture for establishment). When planting in holes that have been augured, the edges of the hole should be gouged to roughen or break up the compacted layer caused by the auger along the edge of the hole.

Seedlings must be planted with the root collar at or less than 1/2 inch below the ground level, this is especially important with conifers. Seedlings with exposed root collars survive poorly.

Soil around the roots must be gently but firmly packed to remove air pockets. Watering after planting helps in removing air pockets as well.

Planting should be in the spring of the year after the frost is out of the ground, and if possible, before local trees/shrubs have begun to leave out.

Water

Available water in the soil must be maximized at the time of planting. This can be accomplished by cultivation and fallowing one year prior to planting. Unless soil moisture conditions are favorable, watering the seedlings at the time of planting will be necessary.

Moisture conservation or supplemental watering shall be provided for plant establishment and growth where natural precipitation is too low for the selected species. Mulch materials such as wood chips or fabricated plastic mulches may be used for moisture conservation. When fabricated mulches are used for water collection/conservation, the minimum area covered per tree or shrub should be 6 feet by 6 feet. When fabricated mulches are used in conjunction with irrigation systems or in areas of 20 inches or greater annual precipitation, this area can be 3 feet by 3 feet. Supplemental watering may be provided by hand watering, flood irrigation, or drip systems.

Windbreak Shelterbelt Measurement

For programs where acreage occupied by a windbreak is needed, calculate the area (length times the width) using length as the length of the windbreak plus 20 feet at each end, and the width as the total of the distances between rows plus 20 feet on each side of the windbreak. A single row windbreak would therefore have a 40 foot width. Repeat this process for each multi-row or single row segment of a system of windbreaks.

Example: A four row windbreak, 1,000 feet long, with 20 feet spacing between the rows would have a linear feet measurement of 1000 feet. The area of the windbreak is 1,040 times 100 feet divided by 43,560 sq. ft. per acre, equaling 2.39 (2.4) acres.

Additional Criteria to Reduce Wind Erosion; Protect Growing Plants

The windbreak will be oriented as close to perpendicular to the troublesome wind as possible.

The interval between windbreaks (single or multiple row segments) shall be determined using current, approved, wind erosion technology. The distance considered sheltered by the barrier shall be 10 times the design height (H). This distance, added to the width of the field where the wind erosion loss is within soil loss tolerance (T) or acceptable soil loss tolerance levels established in the Field Office Technical Guide, determines optimum distances between windbreaks to provide complete field protection using field windbreaks. Interval distances between windbreaks may be increased when considered in conjunction with other erosion control methods such as residue management and grass barriers. Calculations shall account for the effects of other practices in the conservation management system.

For wind erosion control, temporary measures will be installed to supplement the windbreak until it is fully functional.

Sites, fields, and plants are protected within an area 10 times the design height (H) on the leeward side and two times the design height (H) on the windward side of the windbreak.

Secondary windbreaks located on the sides of fields may consist of one or more rows of any adapted tree or shrub species.

When planting field windbreaks within fields on slopes greater than 6 percent, plant on the contour.

Additional Criteria to Manage Snow Deposition

The windbreak will be oriented as close to perpendicular to the snow-bearing wind as possible.

To distribute snow across a field, the windbreak density (during expected snow-producing months)

shall not be less than 25 percent nor greater than 50 percent. The interval between barriers will not exceed 20H. Deciduous trees/shrubs are more suitable than evergreen species for distributing snow.

For snow accumulation, the minimum barrier density, during expected snow-producing months, will be 50 percent.

Windbreaks will be located so that snow deposition will not pose a health or safety problem or obstruct human, livestock, or vehicular traffic. Where property lines allow, windbreak lengths will extend 150 feet beyond each side of the area being protected to minimize impacts of snow drifts caused by end effects. Where a living snow fence will be the only structure or factor keeping snow off a road, the windward row of the living snow fence should be located at least 200 feet from the center line of the road being protected.

Additional Criteria to Provide Shelter for Structures, Livestock, and Recreational Areas

The planting will be oriented as close to perpendicular to the troublesome wind as possible. Where troublesome winds may come from more than one direction, a windbreak may have multiple legs.

For wind protection, the minimum barrier density will be 65 percent during the months of most troublesome wind and the area to be protected will fall within a leeward distance of 10H. A minimum of three rows is generally required to create this density. For year-round protection, at least one row should be evergreen trees. Locate the tallest row of the windbreak approximately 2-5 H from all primary areas in need of protection. Due to the shifting nature of the wind, where property boundaries allow, extend the ends of rows a minimum of 150 feet past the edge of the area needing protection.

Locate livestock protection plantings so that livestock have access to protection from fall/winter/spring winds. With L-shaped belts, lee side protection is available during most storms.

Each corner associated with a pivot irrigation system circle may need a livestock shelterbelt installed on it to adequately shelter livestock inhabiting the pivot irrigated field itself, or to shelter livestock on lands adjacent to the pivot corner. The direction of the troublesome wind that livestock are being protected from should be documented on the planting plan, as well as where the livestock needing protection maybe located. The variety in potential troublesome wind directions can be supported by the Climate Data Index in Section I of the Field Office Technical Guide, within the Soil Erosion Prediction information.

Additional guidance and support for livestock shelterbelt installation can be found on the National Agroforestry Center web page at: http://www.unl.edu/nac/ . At that web site is an Agroforestry Note entitled: Outdoor Living Barn: A Specialized Windbreak, and a publication entitled: Windbreaks for Livestock Operations.

Drainage of snowmelt from the windbreak shall not flow across the livestock area.

Drainage of livestock waste from the livestock area shall not flow into the windbreak.

In designing livestock windbreaks, careful attention must be given to drainage within the windbreak and feedlot. Wet areas caused by poor drainage or melting of drifted snow within the feedlot greatly lessen windbreak caused improvements in weight gain, lowering stress, or the lowering of mortality rates. All windbreaks must be designed to keep drifted snow out of feedlots. All water originating from snow drifts or other sources within windbreaks must be diverted away from feedlots. Water draining from feedlots should be diverted away from windbreaks as well.

Additional Criteria for Noise Screens

Noise screens shall be at least 65 percent dense during all times of the year, as tall as, and as close to the noise source as practicable.

The length of the noise screen shall be twice as long as the distance from the noise source to the receiver.

For high-speed traffic noise, the barrier shall not be less than 65 feet wide. For moderate speed traffic noise, the barrier width shall not be less than 20 feet wide.

Species selected will be tolerant to noxious emissions, sand, gravel depositions, or salt spray from traffic areas.

Additional Criteria for Visual Screens

Visual screens shall be located as close to the observer as possible with a density, height and width to sufficiently block the view.

Additional Criteria for Providing or Enhancing Wildlife Habitat or Travel Corridors.

Plant species selection shall benefit targeted wildlife species Design dimensions of the planting shall be adequate for targeted wildlife species.

To improve the wildlife value of conservation tree and shrub plantings, two or more rows of conifers, shrubs, or a combination of both are recommended on the leeward side. Increasing the number of rows of different tree and shrub species increases the variety of wildlife species that may utilize the site.

To enhance pheasant habitat, rows of shrubs planted to create a .1 acre or larger thicket 100 feet leeward of tree rows helps provide protection during winter blizzards.

Additional Criteria for Improving Irrigation Efficiency

For sprinkler irrigation systems, the windbreak shall be as tall as the sprinkler heads.

The barrier shall not interfere with the operation of the irrigation system.

CONSIDERATIONS

Spacing between windbreaks and rows within windbreaks may be adjusted, within limits of the criteria above, to accommodate widths of equipment used for maintenance. Allow four feet next to each row plus the width of the equipment when this is a consideration.

To enhance aesthetics use evergreen species or species with features such as showy flowers, brilliant fall foliage, or persistent colorful fruits.

Selection of plants for use in windbreaks should favor species or varieties tolerant to herbicides used in the area.

Plants that may be alternate hosts to undesirable pests should be avoided.

All plantings should complement natural features.

Tree or shrub rows should be oriented on or near the contour where water erosion is a concern. Where they are hazards, water erosion or runoff from melting snow should be controlled by supporting practices.

Wildlife should be considered when selecting tree or shrub species.

For optimal carbon storage, select plants that are adapted to the site to assure strong health and vigor and plant the full stocking rate for the site.

Species diversity, including use of native species, should be considered to avoid loss of function due to species-specific pests.

Consideration should be given to adverse offsite effects.

Plants established in cropping systems should have root systems that do not affect crop growth and/or spread from root sprouts.

Consider cultural resources when planning this practice.

Plans and Specifications

Specifications for applying this practice shall be prepared for each site and recorded using approved specification sheets, job sheets, technical notes, and narrative statements in the conservation plan, or other acceptable documentation.

Operation and Maintenance

The following actions shall be carried out to ensure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the

practice (operation), and repair and upkeep of the practice (maintenance):

Replacement of dead trees or shrubs will be continued until the barrier is functional. Where two adjoining trees in a row have died, at least one will be replaced to avoid gaps in functionality. Single row

windbreaks require at least 90% survival to be functional. Multiple row windbreaks require at least 75% survival to be functional.

Supplemental water must be planned for almost all species on all sites. This will be required in case of drought and for the plants to reach their full potential. All trees and shrubs, even those native to an area, are susceptible to extended droughts. Water will have to be planned for the dormant season since severe droughts during this period can have a significant impact on tree health.

An exception to required supplemental water for plantings is in the mountain country where the planted species do grow naturally to their full potential. Plantings with adaptable native plants and a satisfactory mulch may also be exempt from supplemental water requirements.

Where **fabricated mulches** are used to collect/conserve moisture, they will be maintained for a five-year minimum establishment period. Fabricated mulches not protected from sunlight require a five-year minimum ultra violet light resistance treatment. Potential constriction and girdling of tree trunks by mulches should be monitored as trees grow in size.

Drip irrigation systems will be operational for a three-year minimum establishment period**.** Irrigation intervals will lengthen as new plantings age and develop a deeper and more extensive root system. Soak the soil profile within the drip line of the plants thoroughly to a depth of 3 to 5 feet and do not irrigate again until the profile has drawn down to 50 to 60 percent of available water holding capacity. This will require adding drip lines or increasing the area of flooding as the trees mature to provide water for an increasing root zone. Set time will also increase to accommodate an increasing demand for water. Care must be taken to not over water, which can drown out the roots and kill the plants.

Thin or prune the barrier as needed to maintain proper density and plant health to continue its function.

Inspect trees and shrubs periodically and protect from adverse impacts including insects, diseases or competing vegetation. The trees or shrubs will also be protected from fire and damage from livestock and wildlife.

Periodic applications of **nutrients** may be needed to maintain plant vigor.

Root pruning may be used to control roots invading adjacent cropland area. Generally, pruning at the drip line of 20-year-old trees will restrict roots and not affect the health of the tree.

Control of Competing Vegetation

On soils that are not susceptible to severe wind erosion competitive vegetation shall be controlled by the following alternative methods.

- **Between the tree rows**

Clean cultivation with a spring tooth harrow, sweep chisel plow (duckfoot), disk (tandem disk only), shovel cultivator, or other tillage implement.

Tillage depth would be two to four inches to avoid damage to tree roots.

Plant annual cover crops of grain sorghum, oats, corn, forage sorghum, etc. If perennial grasses are used, only short non-rhizomatous grasses such as blue grama, Indian rice grass, etc. will be allowed. Approximately 4 feet should be left between the cover crop and the tree row.

In some cases, chemicals may be used on the entire windbreak area to control competitive vegetation. If this method is used, caution must be taken to avoid severe erosion and concentration of the chemicals from runoff. Comply with chemical labeling and all laws regarding their use.

- **In the tree row (maintain a 3-6 ft. weed free strip within the row)**

Hand hoeing.

Tractor mounted row hoes or weed badgers.

Over the row cultivation with a flexible tine or finger type weeder, effective only when weeds are very young such as the two leaf stage.

Chemical weed control in a 1.5 to 3 foot band adjacent to each side and in the row approximately once each month during the growing season, or use of soil applied herbicides.

A roto-tiller may be used, but not more than 4 inches deep.

Polypropylene fabric mulch must be at least 6 foot wide and meet other requirements as described in criteria.

On sites prepared prior to tree planting, where severe wind erosion is a hazard or where tillage was not possible, competitive vegetation shall be controlled by the following methods.

- **Between the tree rows - tilled sites**

Cover crops of grain sorghum or forage sorghum or other adequate cover crops should be maintained in the area between tree rows. If perennial grasses are used, only short non-rhizomatous grasses such as blue grama and Indian rice grass, etc. will be allowed.

Approximately 4 feet should be left between the cover crop and the tree row.

Between the tree rows - untilled sites or grass cover

Mow between the rows approximately once each month during the growing season.

- **In the tree rows**

Hand hoeing.

Tractor mounted row hoes or weed badgers.

Over the row cultivation with a flexible tine or finger-type weeder, effective only when weeds are very young such as the two leaf stage.

Poypropylene fabric mulch must be at least 6 foot wide and meet other requirements as described in criteria.

Chemical weed control in a 1.5 to 3 foot band adjacent to each side of each plant and in the row approximately once each month during the growing season, or use of soil applied herbicides.

Protection from Animal Damage

The best defense is maintaining good weed control within row and mowing between rows to reduce rodent habitat. Control mice, gophers and other undesirable rodents by the use of poison baits. Mouse baits should be placed in tin cans nailed to a board. Gopher baits are best placed with a machine of the "gopher-getter" type. Follow pesticide directions and heed all precautions on the container label. If they are not handled properly or if unused portions are disposed of improperly, they may cause injury to humans, animals, fish and other wildlife, desirable plants, honey bees and other pollinating insects, and may contaminate water supplies.

Physical Barriers will deter grazing and browsing of plant materials. Acceptable material includes chicken wire with a mesh that does not exceed 1 inch will be shaped to form a cylinder a minimum of 5" in diameter and 18" in height. A minimum of 1 24 inch 1'X2" stake with 18 inches extending above the ground will be used to support the chicken wire. The chicken wire will be fastened to the stake by 2 evenly spaced staples or 2 wire ties. The bottom the cylinder will be flush with the ground. The barrier must be removed when the trunk diameter is within ½ inch of the chicken wire diameter.

Another acceptable physical barrier includes rigid polypropylene mesh tubes. Tubes will be of a diamond pattern with a minimum 30 mil standard diameter. The tubes will be a minimum of a 5-inch diameter and 18 inches high. The tubes will be fastened to a 24" long 1" X 2" stake with 18 " extending above the ground. Attachment will be with a single wire tie or staple. The bottom the cylinder will be flush with the ground.

REFERENCES:

Colorado State Forest Service. 1994. Trees for Conservation, Planning-Planting-Care. CSFS Publication #114-0394, Fort Collins, Colorado

Brandle, J.R.; Hintz, D.L.; and Sturrock, J.W., eds. Windbreak Technology. New York: Elsevier, 1988